Fishery Data Series No. 96-13

Stock Assessment and Biological Characteristics of Burbot in Fielding and George Lakes During 1995

by

James F. Parker

May 1996

Alaska Department of Fish and Game

Division of Sport Fish

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
metric ton	mt
milliliter	ml
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
ounce	oz
pound	lb
quart	qt
yard	yd

Spell out acre and ton.

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
hour (spell out for 24-hour clock)	h
minute	min
second	s

Spell out year, month, and week.

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

All commonly accepted abbreviations.	e.g., Mr., Mrs., a.m., p.m., etc.
All commonly accepted professional titles.	e.g., Dr., Ph.D., R.N., etc.
and	&
at	@
Compass directions:	
east	E
north	N
south	S
west	W
Copyright	©
Corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
et alii (and other people)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.,
id est (that is)	i.e.,
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
number (before a number)	# (e.g., #10)
pounds (after a number)	# (e.g., 10#)
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S. state and District of Columbia abbreviations	use two-letter abbreviations (e.g., AK, DC)

Mathematics, statistics, fisheries

alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	F, t, χ^2, etc.
confidence interval	C.I.
correlation coefficient	R (multiple)
correlation coefficient	r (simple)
covariance	cov
degree (angular or temperature)	°
degrees of freedom	df
divided by	÷ or / (in equations)
equals	=
expected value	E
fork length	FL
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
mideye-to-fork	MEF
minute (angular)	'
multiplied by	x
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
standard length	SL
total length	TL
variance	Var

FISHERY DATA SERIES NO. 96-13

STOCK ASSESSMENT AND BIOLOGICAL CHARACTERISTICS OF BURBOT IN FIELDING AND GEORGE LAKES DURING 1995

by
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ABSTRACT

Indices of abundance were estimated for populations of burbot *Lota lota* in Fielding and George lakes in the Tanana River drainage. Burbot were captured in baited hoop traps. Traps were set in a systematic pattern across each lake. Sampling occurred during May and June of 1995. Estimated mean CPUE per 48-hour set of fully (450 millimeters total length and longer) and partially (300 to 449 millimeters total length) recruited burbot in Fielding Lake was 0.54 (SE = 0.07) and 0.61 (SE = 0.08), respectively. Mean CPUE of fully and partially recruited burbot in George Lake was 0.72 (SE = 0.07) and 0.06 (SE = 0.02), respectively. Abundance of fully recruited burbot estimated with multiple year mark-recapture experiments was 479 (SE = 92) in Fielding Lake in 1994. Fully recruited burbot surviving in Fielding Lake from 1993 to 1994 was estimated at 79.7% (SE = 16.1).

Key words: burbot, *Lota lota*, lakes, abundance, hoop traps, systematic design, mean length, catch-per-unit of effort, abundance estimates, survival rates, recruitment.

INTRODUCTION

Harvests of burbot *Lota lota* from Interior lakes increased, on average, 30% annually from 1977 to 1983, with the largest harvest occurring during the years 1984 to 1986 (Howe et al. 1995). The lakes in the Glennallen area (southcentral Alaska) have historically supported the largest component of this harvest. Harvest of burbot in the Tanana River drainage has been stable (Figure 1).

Burbot harvests have declined in lakes of interior Alaska since peak harvests in the mid-1980's. This decline in harvests can be attributed to decreasing abundance of burbot in lakes due to overfishing and more restrictive regulations governing these sport fisheries. Emergency regulations adopted in 1987 and other regulations have restricted bag and possession limits to two fish and eliminated the use of set lines as a legal method of sport fishing from the Upper Copper/Upper Susitna management area, Fielding, T, and Harding lakes, and throughout the Tangle Lakes system. Regulations for other populations in the Tanana River drainage are a daily bag and possession limit of five burbot and a maximum of five hooks fished at any one time.

Burbot harvests from Fielding Lake were not detected in the Statewide postal survey during 1989-1991 (Mills 1990-1992). No recorded burbot harvest occurred in Fielding Lake from 1989-1991 (Mills 1990-1992). During 1992, 1993, and 1994 there were 51, 32, and 73 burbot harvested from Fielding Lake (Mills 1993-1994; Howe et al. 1995), respectively. The recent decline in the population from 569 fully recruited burbot in 1991 to 256 fully recruited burbot in 1992 (Parker 1994) is attributed to low survival. High fishing mortality prior to 1984 resulted in low recruitment of juveniles. Fewer fish then entered the fully recruited population beginning in 1992. Exploitation on the fully recruited population, even from small harvests, exceeded 17% (Parker 1995). For these reasons the Alaska Department of Fish and Game (ADF&G) issued an emergency order on May 26, 1994, closing Fielding Lake to the taking of burbot until further notice.

Anglers have reported harvests of burbot in George Lake in 14 of the past 18 years (Mills 1979-1994; Howe et al. 1995). Harvest has been as high as 150 fish in 1984 (Mills 1985), and averages 46 fish per year. The population sampled is comprised of nearly 90% fully recruited burbot (Lafferty et al. 1992). Periodic sampling to determine the effects of fishing mortality on a population with little recruitment is warranted.

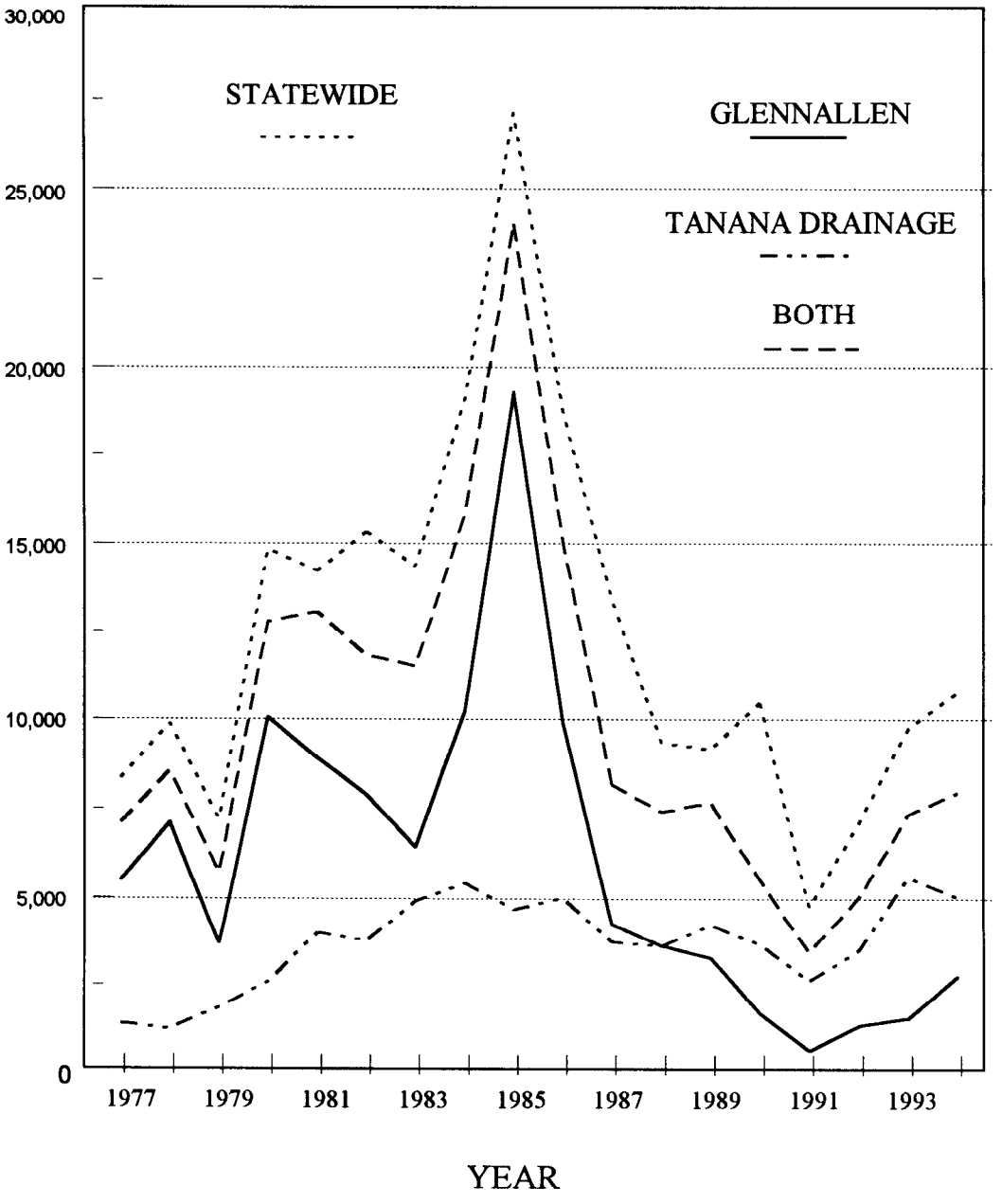

Figure 1.-Harvest in Alaskan burbot fisheries, 1977-1994.

In 1986, the Sport Fish Division initiated a stock assessment program for burbot populations in the Upper Copper/Upper Susitna basin (Region II) and in the Tanana River drainage (Region III; Parker et al. 1987-1989, Parker 1993-1995, Lafferty et al. 1990-1992, Lafferty and Bernard 1993, Taube et al. 1994, 1995). This document is the tenth report of the findings from this research in Region III. The objectives of the program in 1995 are as follows:

1. to estimate the abundance in 1994 and survival rate from 1993 to 1994 for burbot greater than 449 mm total length (TL) in Fielding Lake; and,
2. to index abundance of burbot greater than 449 mm TL in Fielding and George lakes in 1995 with mean catch-per-unit effort (CPUE).

In addition, surviving recruitment, incremental growth, and density of burbot in Fielding Lake were estimated. Each of the populations studied in 1995 has (or had) a popular sport fisheries for burbot. Study populations reside in lakes that are either geographically isolated or are separated from other lakes by lengthy rivers (Figure 2). Descriptions of each study lake are presented in Appendix A1.

METHODS

GEAR DESCRIPTION

Burbot were captured with small hoop traps 3.05 m in length with seven 6.35 mm steel hoops (Figure 3). Hoop diameters tapered from 0.61 m at the entrance to 0.46 m at the cod end. Each trap was double throated (tied to the first and third hoop) with throats narrowing to an opening 10 cm in diameter. All netting material was knotted nylon 25 mm bar meshes, held together with No. 15 cotton twine, and treated with an asphaltic compound. Each trap was stretched with two sections of 12 mm galvanized steel conduit that was attached by snap clips to the end hoops of the trap. A numbered buoy was attached to the cod end of the trap with a polypropylene rope. Each trap was baited with Pacific herring *Clupea harengus pallasi* cut into chunks and placed in a 500 ml perforated plastic, screw-top container. Bait containers were placed unattached in the cod end of the hoop trap. Each hoop trap was soaked for approximately 48 hours (hereafter referred to as a set) to maximize the catch of burbot (Bernard et al. 1991).

STUDY DESIGN

Mean CPUE was estimated in Fielding and George lakes with two-stage, systematic surveys (Table 1). First, an overlay with parallel lines was placed across a map of each lake at a randomly chosen position but with the lines in the overlay perpendicular to the long axis of the lake. Distances between adjacent lines[1] in the overlay represented 125 m. Each parallel line had tick marks that represented a distance of 125 m. Next, the desired number of sets was compared with the tick marks that were over the water on the map; parallel lines were randomly excluded until the tick marks and the desired number of sets were similar. Traps were set in transects corresponding to the position of each remaining parallel line. However, the location of the first set along each transect was randomly chosen, and every subsequent set was along that transect at

[1] The distance between traps of 125 m was chosen to eliminate gear competition. The effective fishing area of a baited trap was estimated at 0.45 ha by dividing the average CPUE of burbot caught per 48-hour set in 1985 in Fielding Lake by the density of burbot per ha from the mark-recapture experiment (Pearse and Conrad 1986). This estimated fishing area was arbitrarily increased to 1.25 ha to ensure elimination of gear competition; this area corresponds to traps set at a distance of 125 m.

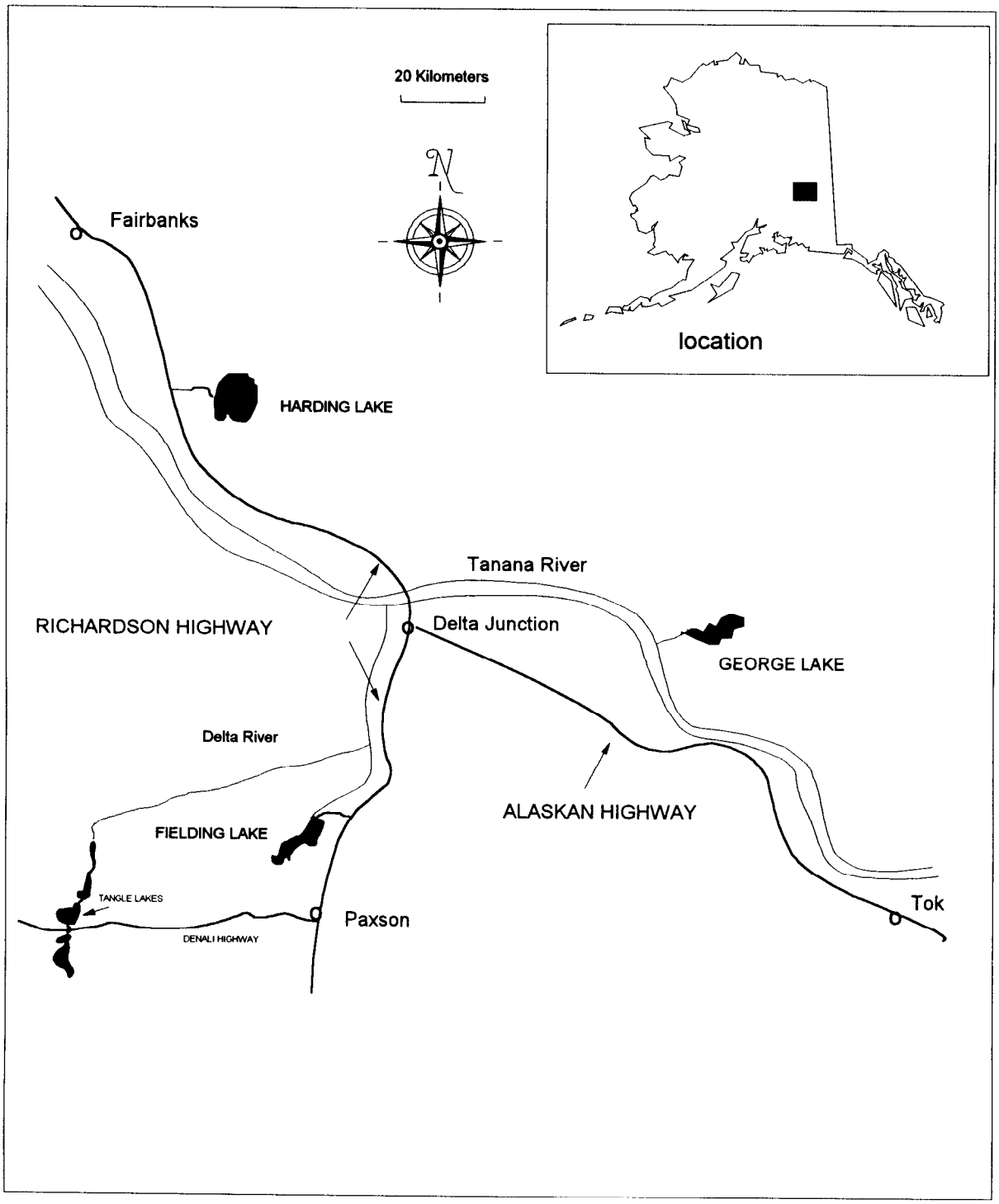

Figure 2.-Location of Fielding and George lakes in the Tanana River drainage.

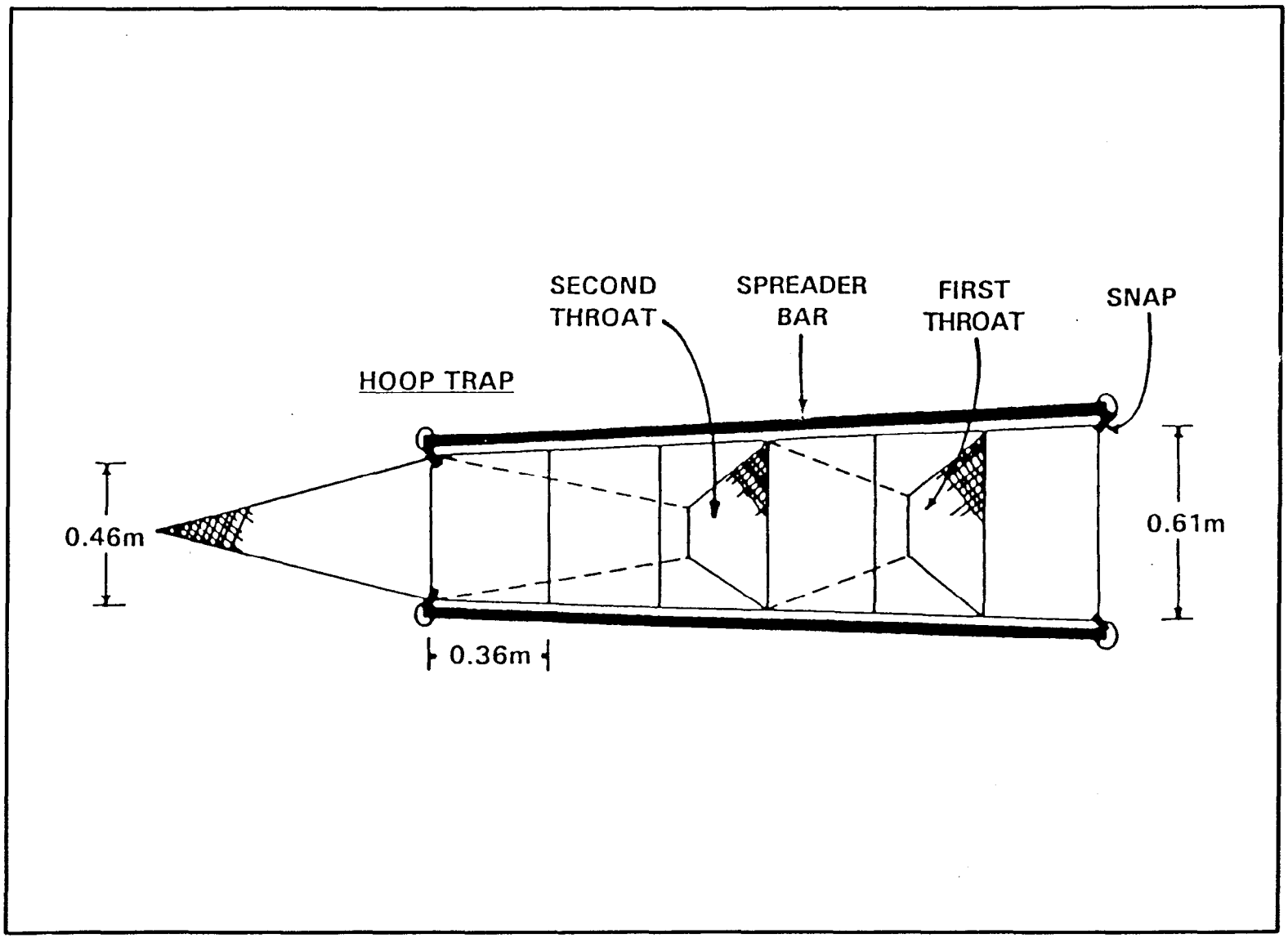

Figure 3.-Schematic drawing of hoop trap used to catch burbot during 1995.

Table 1.-Numbers of sets and dates of sampling events for the stock assessment of burbot populations in Fielding and George lakes in 1995.

Lake	Area (ha)	Sampling Dates	Number of Sets
Fielding	538	June 14 - 20	300
George	1,863	May 19 - 26	361
Totals			661

125 m from the last set. The desired number of sets for each survey in mark-recapture experiment was estimated by dividing an *a priori* estimate of mean CPUE into sample size in numbers of burbot needed for the associated mark-recapture experiment. Sample size for the mark-recapture experiment is based on a previous abundance estimate. The desired number of sets to estimate mean CPUE as an index of abundance was calculated with procedures in Cochran (1977) for determining sample size to estimate the mean of a continuous variable. Desired sample sizes for both mean CPUE and abundance was calculated, and the larger number was used.

Traps were immersed and retrieved during daylight hours beginning on one end of the lake and progressing to the other end. A single crew of three (one person piloted the boat and recorded data while the other two handled traps and measured and tagged captured burbot) immersed and retrieved traps simultaneously. The crew immersed and retrieved 60 traps in an 8-hour work day. Every new set received fresh bait, and old bait was discarded on shore.

Captured fish from each trap were placed into a plastic live tank during sampling. Each burbot was measured and those greater than 300 mm TL was doubly marked. Burbot were tagged with an individually numbered Floy tag inserted in the musculature beneath the dorsal fin. Throughout the mark-recapture experiments, tags were used in serial order to allow easy recognition of specific locations and sampling events. The second mark, which was used to evaluate loss of Floy tags, was a left ventral finclip in George Lake and a right vental finclip in Fielding Lake. Any burbot that was stressed from deep-water removal (usually an expanded gas bladder) or had trap-inflicted injuries was killed and dissected. Otoliths were removed, and the sex and maturity of these burbot were recorded. Ages were estimated from whole, polished otoliths by counting annuli according to the method of Beamish and McFarlane (1987) and Chilton and Beamish (1982). Burbot in Fielding and George lakes were separated into two groups for analysis: those fully recruited to the hoop traps ($\geq$ 450 mm TL) and those partially recruited ($<$ 450 mm TL). Bernard et al. (1991) showed that burbot recruited fully to the hoop trap gear between 450 and 500 mm TL in most populations. In Fielding Lake recaptures during this single event were considered captured only once to estimate abundance with the mark-recapture experiment, but were considered captured "k" times to estimate mean CPUE for both lakes.

MEAN CPUE

Mean CPUE was estimated in Fielding Lake for fully (≥ 450 mm TL) and partially (< 450 mm TL) recruited burbot following a two-stage sampling design with transects as first-stage units and sets along transects as second-stage units (Sukhatme et al. 1984). For George Lake, mean CPUE was estimated for fully recruited (≥ 450 mm TL) only. Although all transects had an equal probability of being included in a survey, they were of different sizes (lengths) depending upon the shape of the lake. Under these conditions, an unbiased estimate of mean CPUE is:

$$\overline{CPUE} = \frac{1}{n} \sum_{i=1}^{n} \frac{1}{m_i} \left[\sum_{i=1}^{m_i} x_i c_{ij} \right] \qquad (1)$$

where:

c_{ij} = catch of burbot from the jth set on the ith transect;

n = number of transects;

m_i = number of sets sampled on the ith transect;

x_i = $M_i / \overline{M}$;

M_i = maximum possible sets on the ith transect; and,

$\overline{M}$ = mean of possible sets across all transects.

Although the M_i and $\overline{M}$ are unknown, the m_i and $\overline{m}$ were used as substitutes because both M and m are directly related to the length of transects.

Thus $\hat{x}_i = m_i / \overline{m}$ was inserted for x_i. Because few burbot enter traps during daylight (Bernard et al. 1991), catches were not adjusted for the few hours deviation in soak times from the standard 48 hours for most sets. Although the distribution of burbot can be related to depth (Odell 1932; Kennedy 1940; Rawson 1951; Dryer 1966), estimate of mean CPUE was not post-stratified by depth because sampling effort was proportionally (or near proportionally) allocated across depths within the survey design. A two-stage, resampling procedure (Efron 1982, Rao and Wu 1988) was used to generate an empirical distribution of mean CPUE for each survey from which variance of mean CPUE and bias from using x were estimated (Bernard et al. 1993).

ABUNDANCE, SURVIVAL RATES, AND RECRUITMENT

Abundance, survival rates, and surviving recruitment of fully recruited burbot (≥450 mm TL) were estimated using the mark-recapture histories of fish according to the models of Jolly (1965) and Seber (1965, 1982). The computer program Jolly (model A) as described in Pollock et al. (1985, 1990) was used to do the calculations. Mark-recapture histories for the population are listed in Appendices A2 and A3. In earlier years, two-event mark-recapture experiments based on closed populations were used to estimate abundance of burbot; both events were a few weeks apart to allow mixing between marked and unmarked burbot. Data from these experiments were pooled to form the annual sampling events used in the multi-year mark-recapture experiment as recommended by Pollock (1982). Since mark-recapture experiments of this type do not produce

estimates of abundance for the current year of sampling, mean CPUE was used to estimate abundance of Fielding Lake burbot in 1995 using the relationship:

$$\hat{N} = A\overline{(CPUE)} \quad \hat{q}^{-1} \tag{2}$$

where A is the surface area the lake, and q is the catchability coefficient (the fraction of the population removed instantaneously with one unit of sampling effort). Estimates of q were obtained from previous sampling in Fielding Lake and George Lake (see Lafferty et al. 1992; Parker 1994, Parker 1995). Since catchability of burbot in hoop traps is about 1.5 times higher just after lakes become ice-free than later in the summer (Bernard et al. 1993), only information from past sampling events that matched the scheduling with the sampling event in 1995 was used to estimate an average q.

RESULTS

For Fielding Lake, length distributions of fully recruited burbot in 1995 were not significantly different than in 1994 (Kolmogorov-Smirnov two-sample test, $P < 0.05$; Figure 4). Results of this hypothesis test are significant at the 90% level ($P = 0.098$). The plot (Figure 4) shows that more burbot were recruited into this size group than in the previous year. The mean length of fully recruited burbot in 1994 was 571 mm TL (Parker 1995) which decreased to 552 mm TL in 1995 (Table 2), confirming an increase in recruits. Fully recruited burbot released in 1993 and recaptured in 1994 grew an average of 30 mm ($n = 26$). The length distribution in 1994 had a steep ascending left limb from 300 to 400 mm (Parker 1995). There was a less abrupt left ascending limb from 300 to 425 mm in 1995 (Figure 5). The mode of the length distribution (470 mm) is greater than the length at full recruitment for the sampling gear (450 mm TL).

Average length of fully recruited burbot in George Lake increased from 638 mm TL in 1991 (Lafferty et al. 1992) to 652 in 1995 (Table 2). Length distribution of the burbot population displayed a flat left limb starting at 300 mm (Figure 5) and rising at 550 mm. In 1991, the length distribution was similar except the left limb increased at 525 mm (Lafferty et al. 1992, Figure 5). The mode of the length distribution for George lake is 680 mm. Fully recruited burbot released in previous sampling periods and recaptured in 1995 grew 29 mm annually ($n = 6$).

In 1995, estimated mean CPUE (bootstrapped) of fully and partially recruited burbot in Fielding Lake was 0.54 burbot and 0.61 burbot per set, respectively (Table 3). Estimated mean CPUE for fully and partially recruited burbot in George Lake was 0.72 and 0.06 burbot per set, respectively (Table 3). Estimated bias in mean CPUE as calculated through bootstrapping was negligible ($< 1.4\%$).

Estimated mean CPUE for fully recruited burbot in Fielding Lake declined annually from 0.71 in 1991 (Lafferty et al. 1992) to 0.32 in 1993 (Parker 1994). In 1994, mean CPUE increased to 0.53 (Parker 1995) and changed only slightly (0.54) in 1995 (Table 3, Figure 6). The mean CPUE of partially recruited burbot increased from 0.42 in 1992 to 0.62 in 1993 (Figure 6) and remained stable in 1994 (0.54) and 1995 (0.61). Sets were most numerous between 11-15 m with burbot being caught at all depths (Figure 7). The last reported CPUE estimate for George Lake was 0.38 in 1991 (Lafferty et al. 1992). Sets in George Lake were predominately in water 1-3 m with burbot caught at all depths (Figure 8).

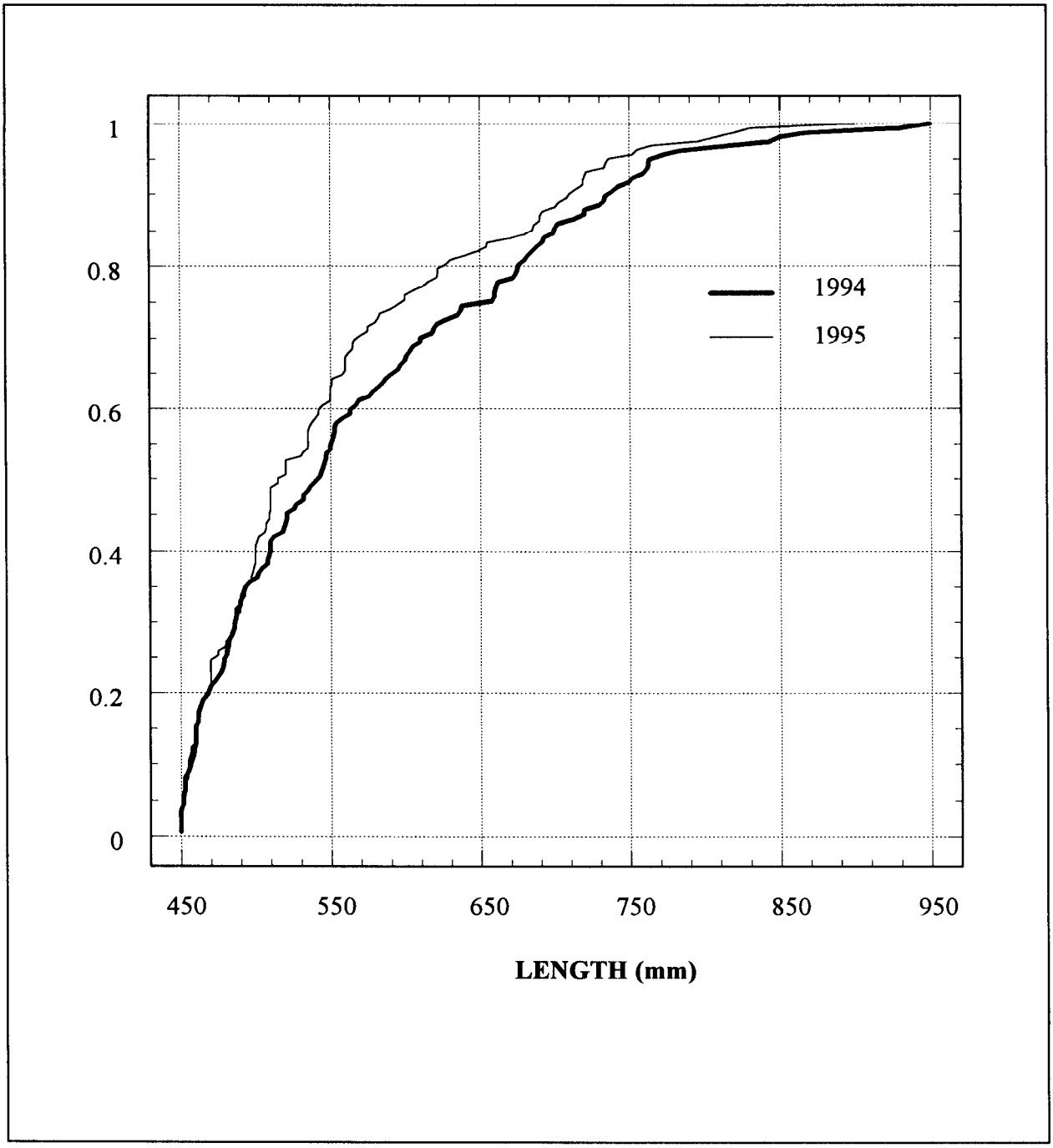

Figure 4.-Cumulative length frequency of burbot captured in Fielding Lake during 1994 and 1995.

Table 2.-Mean lengths (mm TL) of measured burbot during sampling events in Fielding and George lakes in 1995.

		Recruitment to the gear[a]		
Lake	Statistic	Partially	Fully	All
Fielding	Mean	398	552	470
	SE	3	8	6
	Samples	183	162	345
George	Mean	399	652	631
	SE	8	6	7
	Samples	23	259	282

[a] Burbot partially recruited to the gear are < 450 mm TL and fully recruited burbot are ≥ 450 mm TL.

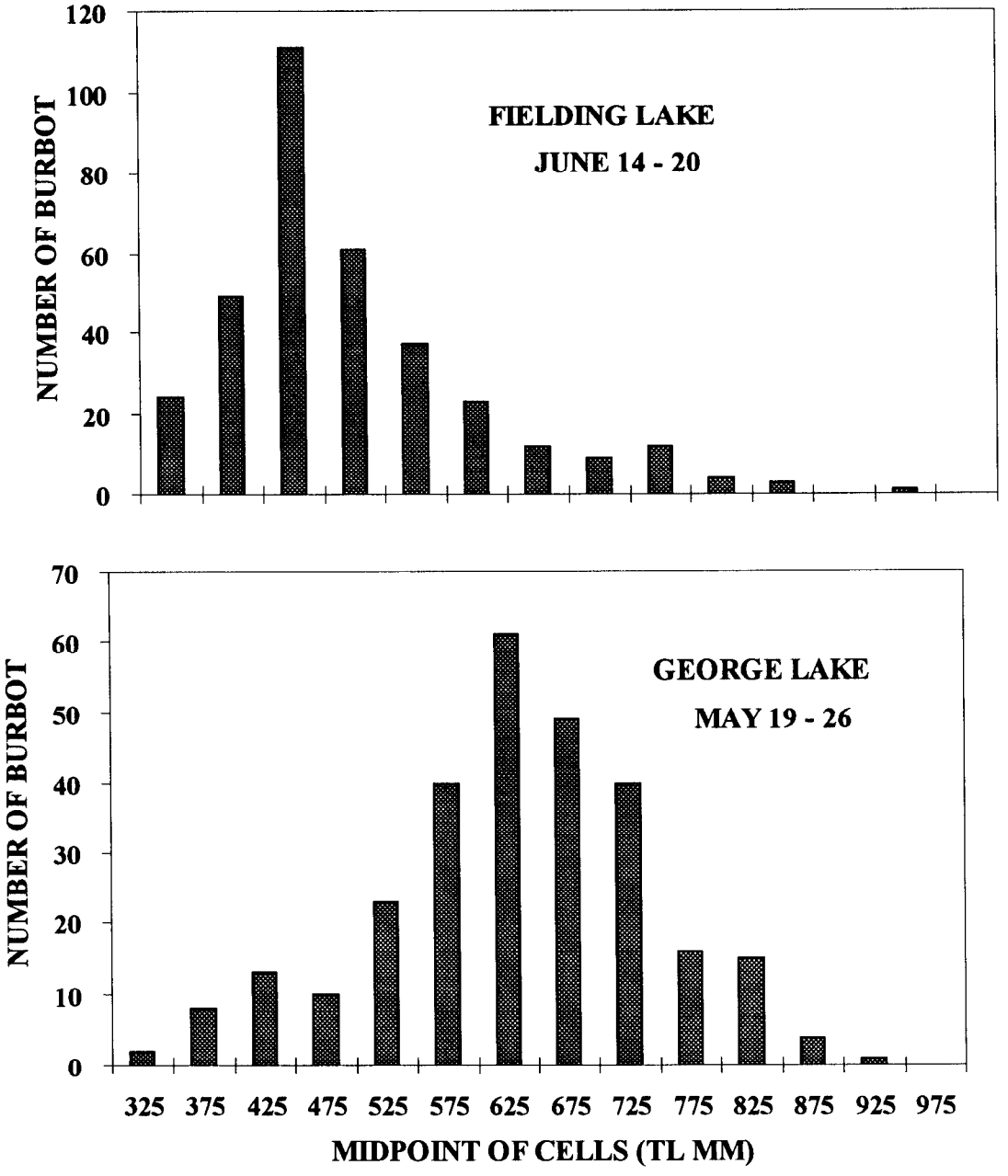

Figure 5.-Length-frequency histogram of burbot captured in Fielding and George lakes in 1995.

Table 3.-Estimated mean CPUE of fully recruited (≥ 450 mm TL) and partially recruited (< 450 mm TL) burbot from systematic sampling of Fielding Lake and George Lake in 1995.

Lake-Dates	Strata	Number of Sets and Transects		Mean CPUE Bootstrapped	Mean CPUE Arithmetic	%D	SE	CV
Fielding								
Full Recruits:								
6/16-22	All depths	300	43	0.54	0.54	0.2	0.07	13.1
Partial Recruits:								
6/16-22	All depths	300	43	0.61	0.61	0.1	0.08	12.9
George								
Full recruits:								
5/19-26	All depths	361	43	0.72	0.72	0.1	0.07	10.2
Partial Recruits:								
5/19-26	All depths	361	43	0.06	0.06	1.4	0.02	27.3

Estimated abundance of fully recruited burbot (410) decreased in 1995 from a 1994 abundance of 479 fish (Table 4). However, it is doubtful that this is a significant decrease in abundance due to the behavior of the Jolly-Seber model with limited sampling events. The recent increases in fully recruited burbot in Fielding Lake in the past two years demonstrates a cyclic pattern over the past ten years (Figure 9). Annual survival rate from 1993-1994 was estimated at 80%, and surviving recruitment was estimated at 215 (Table 4). Density of fully recruited burbot in 1995 was 0.89 fish per hectare (SE = 0.17) which is recovering toward the 1991 estimate of 1.10 fish per hectare (SE = 0.18, Parker 1993). Rate of overwinter tag loss was 13% for fully recruited burbot. Throughout the mark-recapture experiment, there was no evidence of regenerated fins on any of the recaptured burbot with tags. Abundance of fully recruited burbot in George Lake was estimated at 3,201 using catch statistics. Table 5 contains statistics on catchability coefficients that were used for the 1995 estimate of abundance in both Fielding and George lakes. Variability observed in the catchability coefficient in Fielding Lake is influenced by varying population abundances over time. In 1995, 17 fish were killed incidental to sampling in Fielding Lake, age, weight, and length information collected from these fish are found in the Appendix A4. Finally, Appendix A5 provides a listing of the data archives.

DISCUSSION

Potential bias in the Fielding Lake estimate of abundance, survival rate, and recruitment from the mark-recapture experiment was negligible. Only four of the 31 fully recruited recaptured burbot, marked in 1994, lost their tags. Secondary marks allowed these recaptures to be identified to the marking event. No immigration or emigration has ever been observed from Fielding Lake. Sampling recommendations in Bernard et al. (1991) have been followed closely to avoid other potential bias in estimates mentioned above.

High fishing mortality prior to 1984 resulted in poor recruitment of juveniles. These fish enter the fully recruited population in low numbers beginning in 1992 (Parker 1994). Harvest in 1992 and 1993 even though small, has a high exploitation of 17% and 10%, respectively. Fishing for burbot was closed in May of 1994 however, a harvest of 73 burbot was reported (Howe et al. 1995) for an exploitation of 15%. Harvest during low recruitment will contribute to variable abundance of fully recruited burbot.

The abundance of fully recruited burbot in Fielding Lake between 1992 and 1993 remained nearly the same. Abundance increased significantly in 1994, as did survival of fully recruited burbot, a healthy prospect for the population. While current estimates of abundance, recruitment, and survival rates from the mark-recapture experiment will change as time passes (statistics will become more accurate with more sampling events), the mean CPUE in 1995 indicates that abundance is stable or will slightly decrease in 1995 (Table 4).

The population of fully recruited burbot in George Lake (3,201) is similar to the last reported estimate in 1990 (3,492, Lafferty et al. 1992). Harvests averaging 46 per year and as high as 143 burbot, appear to be sustainable. Unlike most lakes in the Tanana River drainage, partially recruited fish in George Lake are but a small fraction of the population. In 1991, partially recruited burbot comprised 12.4% of the sample and 7.4% in 1995. Recruitment would fail to maintain current population size if significant increases in harvest were to occur.

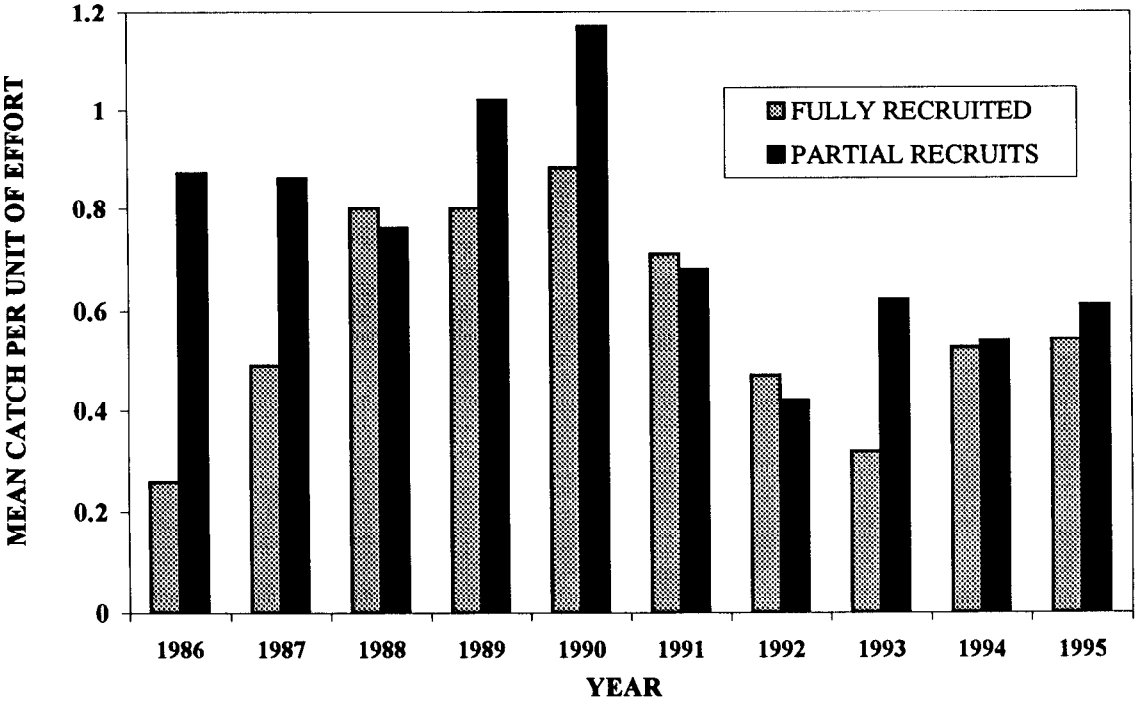

Figure 6.-Mean CPUE of fully recruited (≥ 450 mm TL) burbot captured in Fielding Lake during spring sampling events from 1988 - 1995.

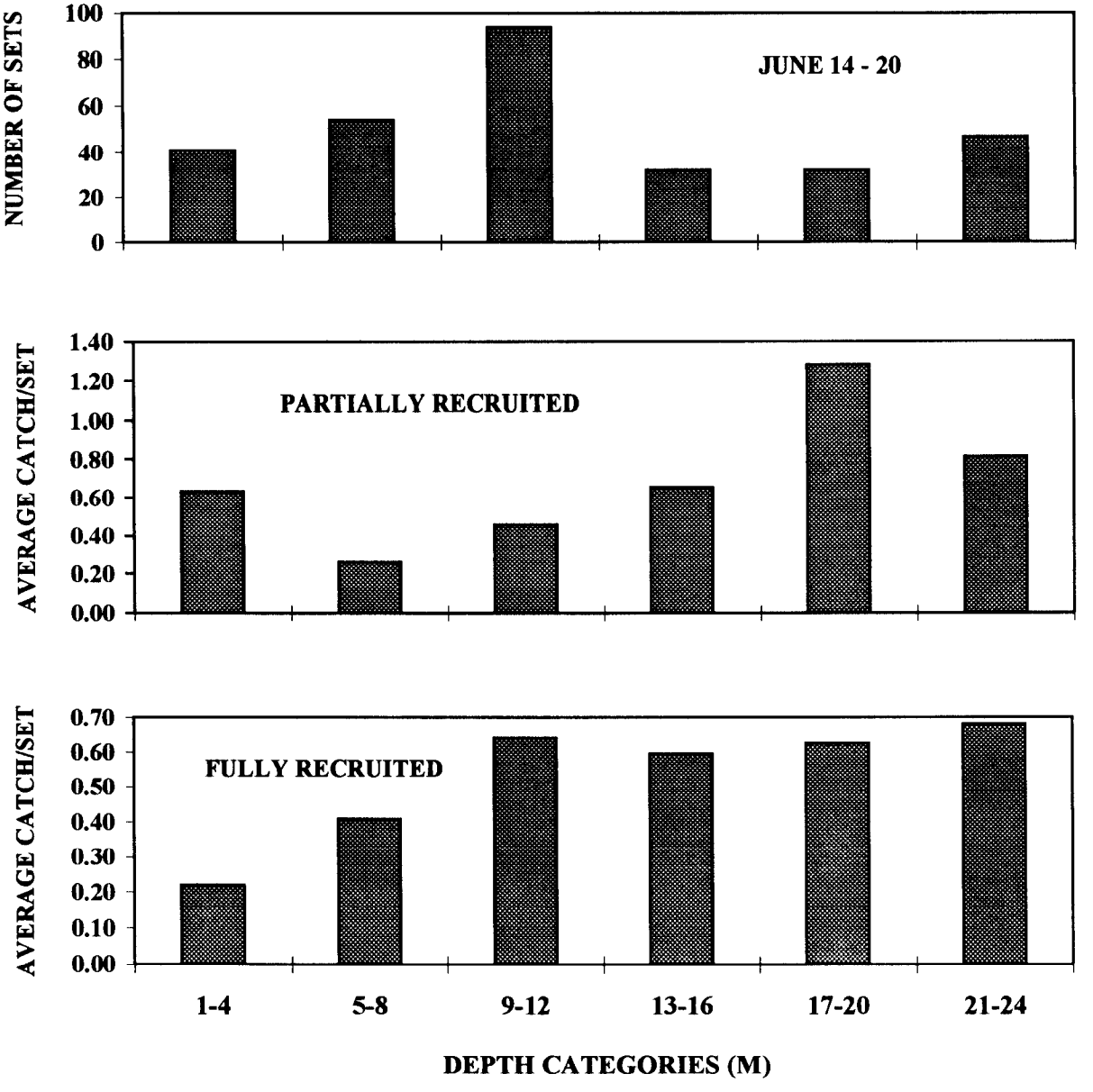

Figure 7.-Frequency of sets by depth and average catch of burbot by depth for Fielding Lake during 1995.

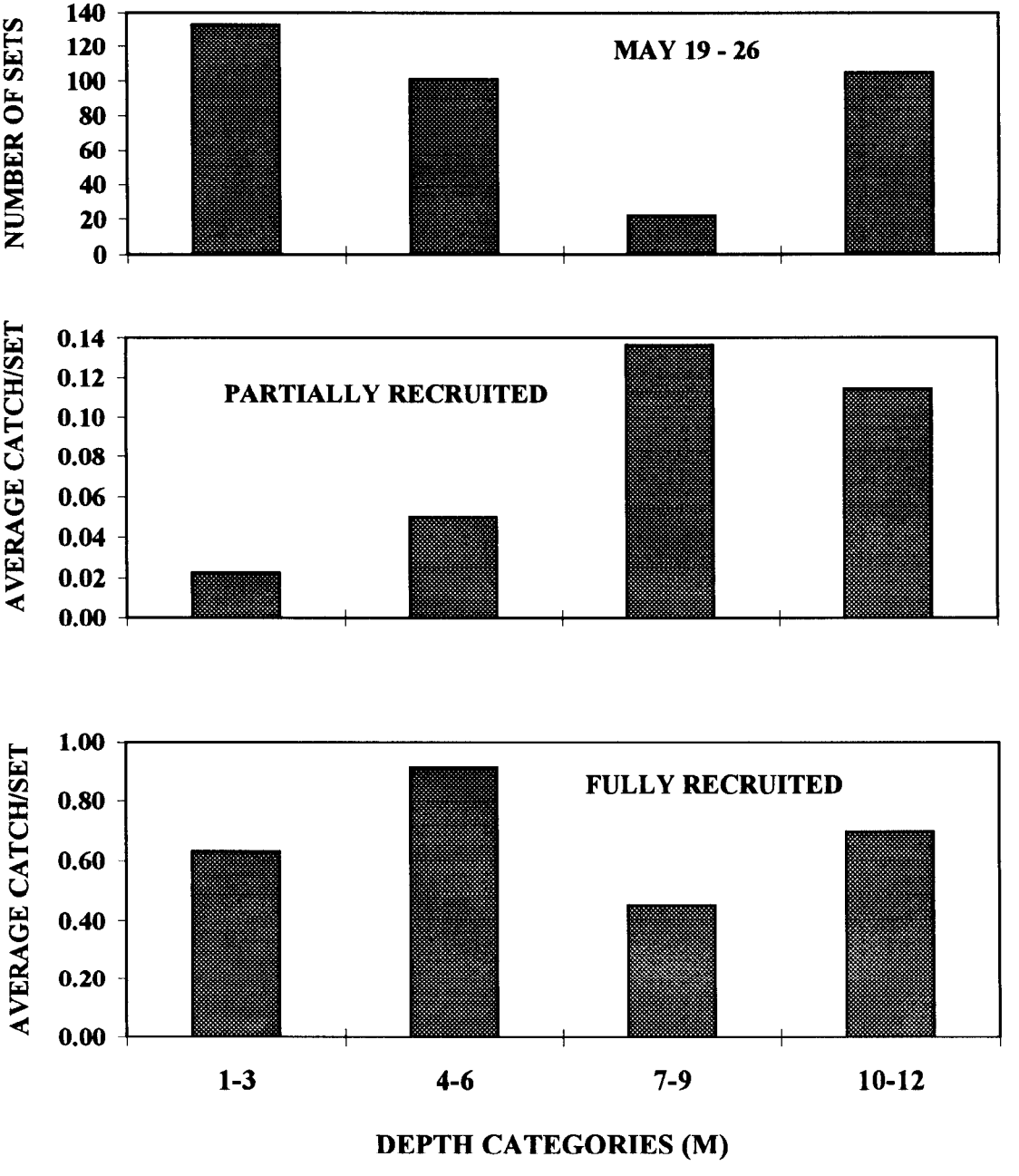

Figure 8.-Frequency of sets by depth and average catch of burbot by depth for George Lake during 1995.

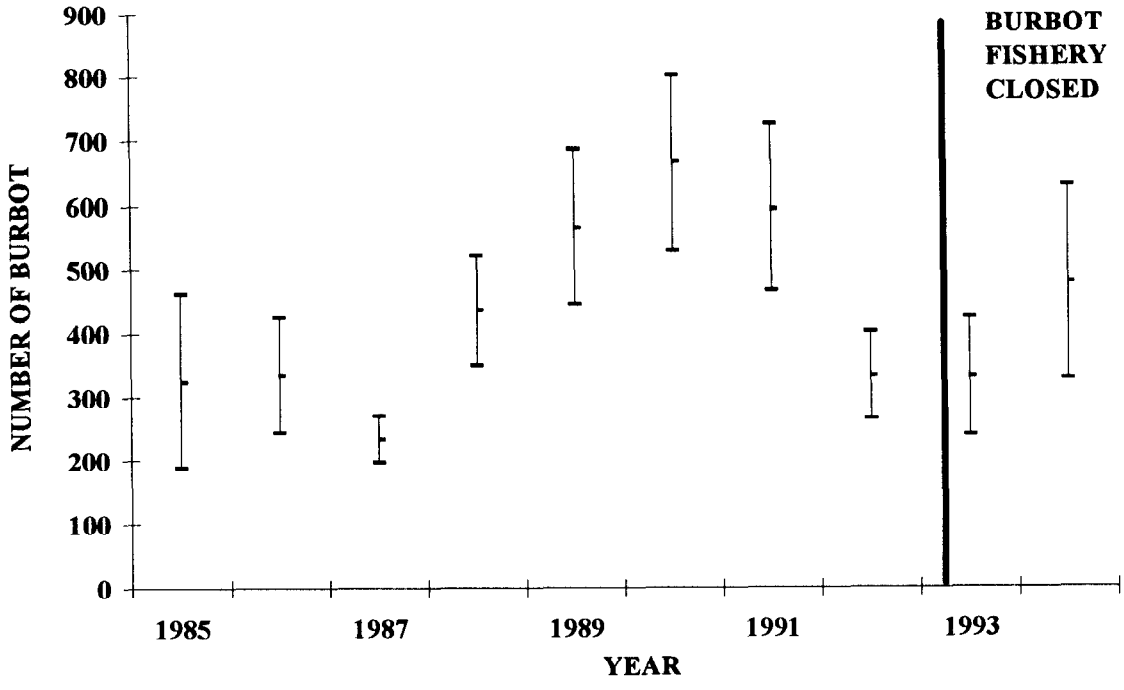

Figure 9.-Fully recruited burbot abundance estimates (± 2 SE) for Fielding Lake from 1986-1995.

Table 4.-Estimates of abundance, survival rate, and recruitment for fully recruited (≥ 450 mm TL) burbot in Fielding Lake.

		Days							
	Midway	Between	Abundance			Survival Rate %		Recruitment	
Lake	Date	Events	Est.	(SE)	CV %	Est.	(SE)	Est.	(SE)
Fielding	7/14/84		N/A						
		403				64.9	13.7	N/A	
	8/21/85		325	83	25.7				
		355				54.7	7.0	170	72
	8/11/86		335	55	16.5				
		360				67.0	7.0	38	35
	8/06/87		234	23	9.6				
		343				92.0	8.5	242	45
	7/15/88		437	52	12.0				
		365				81.0	9.1	233	62
	7/15/89		566	73	13.0				
		367				70.3	8.2	270	69
	7/17/90		665	82	12.4				
		368				69.1	8.8	137	61
	7/20/91		595	78	13.2				
		335				48.4	6.7	46	31
	6/27/92		334	42	12.5				
		361				66.5	10.8	110	38
	6/23/93		332	57	17.1				
		361				79.7	16.6	215	62
	6/19/94		479	92	19.2				
		363							
	6/17/95		410						

Table 5.-Spring catchability coefficients for fully recruited burbot (≥ 450 mm TL) in Fielding and George lakes from 1988 - 1994.

Lakes and Dates	Mean CPUE	Abundance[a]	Density	Catchability Coefficient[b]
Fielding Lake:				
6/29/88	0.81	437	0.81	1.00
6/26/89	0.81	566	1.05	0.77
6/16/90	0.88	665	1.24	0.71
6/24/91	0.71	595	1.11	0.64
6/27/92	0.46	334	0.62	0.75
6/23/93	0.32	332	0.62	0.52
6/22/94	0.53	479	0.89	0.59
Spring Average				0.71
George Lake:				
6/15/87	0.39	1,773	0.95	0.41
5/27/88	0.70	3,166	1.70	0.42
6/6/89	0.98	3,450	1.85	0.53
5/26/90	0.61	3,492	1.87	0.33
Spring Average				0.42

[a] Jolly-Seber multi-year mark-recapture estimate, unless otherwise noted.

[b] Mean CPUE multiplied by surface area (538 ha) divided by abundance.

Fielding and Harding lakes are the only two roadside lakes in the Tanana River drainage that are productive enough to support a burbot fishery. A small sustainable level of harvest (10%) can be allowed in Fielding Lake once the population increases to past abundance levels (700-900) burbot.

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APPENDIX A

Appendix A1.-Description of Fielding and George lakes.

FIELDING LAKE (63°10' N, 145°42' W) is accessible by road 3 km southwest of the Richardson Highway. Fielding Lake is 538 ha with a maximum depth of 24 m and an elevation of 906 m. Three major inlets enter Fielding Lake with the outlet on the north end of the lake entering Phelan Creek. The lake begins to freeze by mid-October and breakup occurs from June 15th to July 1st. Campground and boat launch facilities are located at the mouth of the outlet, and 15 to 20 recreational cabins are located along the south shore. Fielding Lake contains Arctic grayling *Thymallus arcticus*, burbot, lake trout *Salvelinus namaycush*, and round whitefish *Prosopium cylindraceum*,.

GEORGE LAKE (63°47'N, 144°31' W) is located approximately 72 km southeast of Delta Junction across the Tanana River. George Lake is accessible by plane or boat in the summer months and by snowmachine during a limited time when the Tanana River is frozen (February 1 - April 15). The lake is 1,863 ha with a maximum depth of 11 m and an elevation of 389 m. There are only two private recreational cabins on George Lake. The Dot Lake Native Corporation (Dot Lake, Alaska) owns most of the shoreline, and permission is required for access for recreational purposes. Sport fishing for northern pike *Esox lucius* is popular just as the ice leaves the lake in the spring when these fish congregate at the shallow west end of the lake to spawn. George Lake also contains Arctic grayling, burbot, humpback whitefish *Coregonus pidschian*, least cisco *Coregonus sardinella*, longnose suckers *Catostomus catostomus*, and round whitefish.

Appendix A2.-Mark-recapture histories of fully recruited[a] burbot by year in Fielding Lake (by sampling event in 1995).

Fielding Lake												
Date:	Year	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
	Beginning	7/20	7/16	7/28	7/21	6/29	6/26	6/16	6/22	6/24	6/20	6/16	6/14
	Ending	10/8	9/27	8/25	8/22	7/31	8/04	8/17	8/18	6/30	6/26	6/22	6/20
NUMBER OF FULLY RECRUITED BURBOT:													
Recaptured from Event 1		0	13	2	2	0	2	0	0	0	0	0	0
Recaptured from Event 2			0	27	23	1	1	1	2	0	0	0	0
Recaptured from Event 3				0	30	9	2	1	0	2	0	0	0
Recaptured from Event 4					0	48	18	4	6	4	0	0	0
Recaptured from Event 5						0	38	16	7	7	2	0	2
Recaptured from Event 6							0	51	13	5	0	2	1
Recaptured from Event 7								0	52	18	3	6	2
Recaptured from Event 8									0	38	8	6	5
Recaptured from Event 9										0	29	16	5
Recaptured from Event 10											0	24	8
Recaptured from Event 11												0	31
Recaptured from Event 12													0
Captured with Tags		0	13	29	55	58	61	73	80	74	42	54	54
Captured without Tags		43	149	90	93	117	120	152	108	67	45	103	99
Captured		43	162	119	148	175	181	225	188	141	87	157	153
Released with Tags		43	138	76	126	149	177	223	187	140	87	156	145

[a] Fully recruited burbot are ≥450 mm TL.

Appendix A3.-Mark-recapture histories of partially recruited[a] burbot by year in Fielding Lake (by sampling event in 1995).

Fielding Lake												
Date:	Year	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
	Beginning	7/20	7/16	7/28	7/21	6/29	6/26	6/16	6/22	6/24	6/20	6/16	6/14
	Ending	10/8	9/27	8/25	8/22	7/31	8/04	8/17	8/18	6/30	6/26	6/20	6/20
NUMBER OF FULLY RECRUITED BURBOT:													
Recaptured from Event 1		0	19	6	0	1	0	0	0	0	0	0	0
Recaptured from Event 2			0	50	23	4	4	0	0	0	0	0	0
Recaptured from Event 3				0	29	13	2	0	0	0	0	0	0
Recaptured from Event 4					0	28	5	2	0	0	0	0	0
Recaptured from Event 5						0	31	5	0	0	0	0	0
Recaptured from Event 6							0	38	5	0	0	0	0
Recaptured from Event 7								0	24	2	4	0	0
Recaptured from Event 8									0	12	6	0	0
Recaptured from Event 9										0	13	7	0
Recaptured from Event 10											0	11	6
Recaptured from Event 11												0	9
Recaptured from Event 12													0
Captured with Tags		0	19	56	52	46	42	45	29	14	23	18	15
Captured without Tags		65	432	278	230	175	244	274	168	112	142	143	164
Captured		65	451	334	282	221	286	319	197	126	165	161	179
Released with Tags		65	404	233	163	152	279	308	194	121	158	160	170

[a] Partially recruited burbot are <450 mm TL.

Appendix A4.-Weights, lengths and estimated ages of burbot killed in Harding and Fielding lakes in 1995.

Date & Lake	Tag Number	Sex	Age	Length (mm)	Weight (g)	Maturity
HARDING:						
9/17/91[a]			7	568		na
9/17/91			6	425		na
9/17/91			6	545		na
9/18/91	64137		10	716		Mature
9/18/91			6	421		na
9/18/91			8	607		na
9/18/91	71288		7	560		na
9/19/91	71199		8	633		na
9/19/91	20077		9	589		na
9/19/91			5	578		na
9/21/91	64171		5	514		na
9/21/91			9	529		na
9/21/91			6	520		na
9/21/91			5	429		na
9/22/91			5	386		na
9/23/91			9	614		na
9/23/91			8	531		na
9/24/91	71165		6	479		na
FIELDING:						
6/18/95	8987	F	6	344	275[b]	Immature
6/18/95	8982	M	5	422	475	Immature
6/18/95	8980	M	7	389	450	Immature
6/18/95	9731	F	7	453	700	Immature
6/19/95	70431	M	9	570	1250	Mature
6/19/95	13684	F	7	470	675	Immature
6/19/95	8739	F	7	500	850	Immature
6/19/95	13693	M	7	400	450	Immature
6/19/95	13695	M	6	415	400	Immature
6/19/95	63635	F	19	733	2500	Mature

-continued-

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Date & Lake	Tag Number	Sex	Age	Length (mm)	Weight (g)	Maturity
6/19/95	9096	M	15	595	1250	Immature
6/19/95	13752	M	16	566	1200	Immature
6/20/95	70297	F	10	710	3000	Mature
6/20/95	13763	M	7	421	425	Immature
6/20/95	9649	F	7	420	500	Immature
6/20/95	13769	F	6	411	400	Immature
6/20/95	13726	F	5	339	300	Immature
6/20/95	9649	F	7	420	500	Immature
6/20/95	9649	F	7	420	500	Immature
6/21/94	8806	F	7	450	600	Immature

[a] Burbot captured during Arctic char studies in 1991.
[b] Weight in grams.

Appendix A5.-Summary of data archives.

Location	Project Leader	Storage Software and version
Region III Delta Junction	J. F. Parker 895-4632	Comma delimited ASCII files Standard RTS Archive format [a]

	Data Map		
Lake	File Name	Data Format	Software
Fielding	U0130HA5.DTA	Hoopnet	RTS-ASCII
	FIEL95TD.DBF	Tag History	DBASE
George	U0110HA5.DTA	Hoopnet	RTS-ASCII

Definitions of Data Formats:

Hoopnet: a mark-sense form developed by Alaska Department of Fish and Game, Division of Sport Fish-Research and Technical Services (RTS) for the recording of trap, catch, and tagging information.

Tag History: a Dbase file that contains lake specific historical tagging information by individual tags and recaptures by sampling events.

Specific codes and organization of columns for each data format are available on request from RTS.

[a] Alaska Department of Fish and Game - Sport Fish Division - Research and Technical Services (RTS).